AD-A136 464 FIELD TEST OF IRREVERSIBLE HUMIDITY INDICATOR(U) AIR 1/1
FORCE PACKAGING EVALUATION AGENCY WRIGHT-PATTERSON AFB
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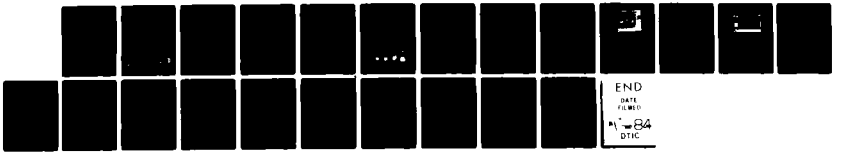

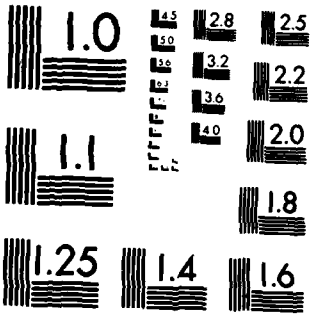

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AFPEA PROJECT NO. 82-P7-314

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FIELD TEST OF IRREVERSIBLE HUMIDITY INDICATOR

HQ AFLC/DSTZ
AIR FORCE PACKAGING EVALUATION AGENCY
Wright-Patterson AFB OH 45433

1 December 1983

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ABSTRACT

~~OBJECTIVE:~~ To determine the effectiveness of irreversible relative humidity (RH) indicators in the storage environment of DOD organizations throughout the Continental United States (CONUS).

APPROACH: Twelve DOD organizations participated in a twelve month field test of irreversible RH indicators which were installed in various types of containers with a variety of items. The indicator, which turns to a dark orange/brown color after exposure at 55% RH, will not reverse (even in a dry environment) as do the blue (low RH)/pink (high RH) reversible types. The reversible type can be affected by temperature/sunlight without an actual change in humidity.

SUMMARY: The test revealed that the indicator will provide a positive and permanent indication of early stage moisture intrusion before corrosion takes place. Additionally, the test revealed that 12% of test containers with actual stored items indicated a RH above 55% even though the blue/pink reversible reference elements indicated RH levels below 50%.

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Additionally, special thanks to the following AFPEA personnel for their participation in this test program:

John Armstrong, Acquisition Packaging Division

Edward Kowalski, Design Division

Ernest Vanzant, Design Division

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INTRODUCTION

Early in 1982, the Air Force Packaging Evaluation Agency (AFPEA) invited several DOD organizations to participate in a twelve month field test of an irreversible relative humidity (RH) indicator. Initially, sixteen organizations expressed interest; however, only twelve submitted test data at the end of the test period which was terminated during the third quarter of 1983. The participating organizations included the Air Force, Army, Navy and Marines. Organizational names and points of contact are listed in Appendix I.

DESCRIPTION OF TEST INDICATOR

The 0.80 inch diameter X 0.13 inch thick indicator is made from a white blotter type material which encapsulates orange crystals that will dissolve at approximately 55% RH. When the indicator trips (stains) the orange fluid will penetrate the porous material and appear as an orange spot on the outer surface of the indicator. Eventually, the orange spot will turn to a dark brown color. A transparent plastic vapor barrier material is bonded to the front surface to prevent the ambient humidity from tripping the indicator. This indicator is identified in the AGM Container Controls, Inc. catalog as a "Delayed Response Maximum Humidity Indicator, P/N TA 378-HC-MHI." It can be installed in AGM's housing (plug) TA 456, TA 356, TA 350, or any MIL-I-26860 type humidity indicator plug. Manufacturer's data states the following features:

a. Unaffected by temperature.

b. RH below 55% will not cause indicator to trip (stain), regardless of duration.

c. Indicator will trip (stain) when exposed to a RH range of 55% for a continuous eight hour period or at 85% RH for a continuous two hour period. Figure 1 shows the various stages of the dissolved crystals beginning with the unexposed indicator to maximum flow conditions.

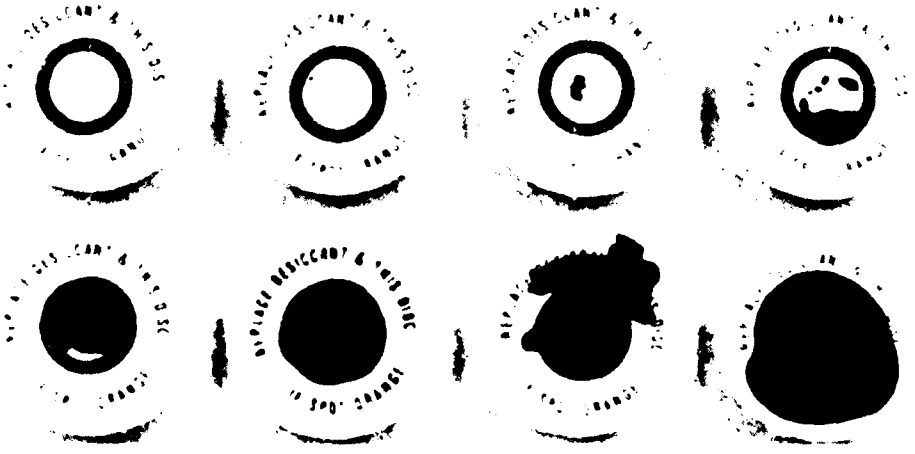

Figure 1. Photograph of Dissolved Crystals

TYPE TEST CONTAINERS/ITEMS

One hundred and thirty-eight containers were used for this study. The type and quantity of containers are listed in Table I.

TYPE	Metal	Fiberglass	Plastic	Drums	Fiberglass Vans 8' X 8' X 30'
QUANTITY	47	31	26	28	6

Table I. Type and Quantity of Containers

The majority of containers were small which reduced or eliminated seal leakage problems.

Twenty-three different types of stored items were available at the various storage sites. They included fuel tanks, electronics, missiles, engine components and miscellaneous mechanical components. In addition, empty containers with small metal test plates and empty containers without desiccant were used for this test series.

TEST PROCEDURE

Each participating organization used an identical test plan (with instructions) to assure uniformity of the test procedure. Some additional and special requirements to the test plan are identified at the end of this section. The test procedure is summarized as follows:

1. Selection of containers with a humidity indicator plug to accommodate the irreversible indicator disc.

2. When possible, the selection of containers with actual stored items.

3. Outside storage area was recommended.

4. Containers were desiccated in accordance with current practices.

5. Selection of a variety of items with slow "turn-a-round" times.

6. Recommended the use of as many containers as practical (some organizations had prepared up to 30 containers for their test series).

7. Inspection of stored item for signs of corrosion prior to and after test.

8. Installation of a reversible 3-spot type MS20003 RH indicator (see Figure 2), or equal, on the inside wall next to the test indicator. This RH reference datum was recorded at the end of the test series.

Figure 2. Photograph of MS20003 Indicator

9. Provided test identification numbers for each container.

10. Instructions for handling and installing the test indicator were provided with each test plan. The installation instructions are listed in Appendix II.

11. Each organization used the special data sheets supplied by AFPEA to simplify the recording process. A copy of a data sheet, with actual test data, is shown in Figure 3.

12. After the twelve month test period, all test data were returned to AFPEA For evaluation and consolidation.

NOTE: All test indicators were supplied from the same manufactured batch.

Additional Requirements: Because of a lack of slow "turn-a-round" items the Naval Air Rework Facility in Alameda CA, supplemented the standard test with a test plan which is summarized as follows:

1. Twenty identical drum containers were modified by adding two MIL-I-26860 plugs to accommodate both the test indicator and a standard cobaltous chloride disc. Additionally, a MS20003 3-spot card indicator was taped to the inside of each container.

2. Twenty identical cold-rolled steel test plates were bent at 90^{0}, cleaned, and preserved with a corrosion preventive compound and placed at the bottom of the container, with the plate laying on its side.

3. Five containers were sealed for storage in the normal manner. The interior of the containers was clean and dry.

4. Five additional containers were sealed in the normal manner except each had 8 ounces of tap water added.

5. Five containers had a one-inch section removed from the sealing gasket.

6. Five containers were sealed without their sealing gaskets.

7. Each of the twenty containers included seven each 1/6 unit bags of desiccant.

Special Requirements: The AFPEA Design Division selected six sets of two identical containers each and installed two MIL-I-26860 plugs in each container. A 3-spot standard cobaltous chloride disc and an irreversible disc were installed as shown in Figure 4. The container sizes varied from camera cases to fuel tank containers. A small piece of unprotected steel plate was located next to the indicator plugs on the inside of the containers. Additionally, some of the container positions were periodically changed to determine the effect of the sun on both the reference and the irreversible indicators.

1 TEST OF IRREVERSIBLE HUMIDITY INDICATOR DISC, SINGLE SPOT

2 TEST COORDINATOR AT W-PAFB: F. JARVIS, AV 785-6901/3226 OR J. ARMSTRONG

3 TEST LOCATION: SYMBOL PTPD, BASE WPAFB, STATE OH

4 INSPECTOR'NAME (NOT MANDATORY): E.J. Kowalski/W.G. Moss

5 CONTAINER CODE: D = DRUM F = FIBERGLASS M = METAL P = PLASTIC O = OTHER (EXPLAIN):

6 INSPECTION PERIOD	7 I.D. NUMBER: A-1 8 CONTAINER CODE: M 9 CONDITION OF ITEM N/A BEFORE:___ AFTER:___		I.D. NUMBER: A-2 CONTAINER CODE: M CONDITION OF ITEM N/A BEFORE:___ AFTER:___		I.D. NUMBER: B-1 CONTAINER CODE: M CONDITION OF ITEM N/A BEFORE:___ AFTER:___		I.D. NUMBER: B-2 CONTAINER CODE: M CONDITION OF ITEM N/A BEFORE:___ AFTER:___	
	10 INSP. DATE	11 COLOR OF TEST DISC	INSP. DATE	COLOR OF TEST DISC	INSP. DATE	COLOR OF TEST DISC	INSP. DATE	COLOR OF TEST DISC
1st DAY	6/28/82	white	6/28/82	white	6/28/82	white	6/28/82	white
2nd DAY	6/29/82	white	6/29/82	white	6/29/82	white	6/29/82	white
3rd DAY	6/30/82	white	6/30/82	white	6/30/82	white	6/30/82	white
1st MO.	7/26/82	white	7/26/82	white	7/26/82	white	7/26/82	white
3rd MO.	9/27/82	white	9/27/82	white	9/27/82	white	9/27/82	white
6th MO.	12/27/82	white	12/27/82	white	11/29/82	spotted	11/29/82	spotted
9th MO.	3/28/83	white	3/28/83	white				
12th MO.	6/27/83	white	4/7/83	spotted				
13 REF. IND	%R.H. 48 TEMP(°F) 87		%R.H. 92 TEMP(°F) 51		%R.H. 76 TEMP(°F) 43		%R.H. 76 TEMP(°F) 43	

12 I.D. NR.	TPO/NSN/REMARKS
A-1, F-4, 370 gal Nested Fuel Tank Container	TPO/NSN# Contract #: F33601-76-90605 S.N. #2 Prototype
A-2, F-4 370 gal Nested Fuel Tank Container	TPO/NSN# Contract #: F33601-76-90605 S.N. #1
B1, Maverick Missile Container	TPO/NSN# FSN 8140-170-6579 S.N. 584
B-2, Maverick Missile Container	TPO/NSN# FSN 8140-170-6579 S.N. 15561

INSTRUCTIONS: BLOCKS 1 THRU 5: Self Explanatory.
BLOCK 6: IF INSPECTION PERIOD IS OTHER THAN RECOMMENDED, RECORD CHANGES IN REMARKS COLUMN (BLK 12).
BLOCK 7: ASSIGN AN I.D. NUMBER FOR THE TEST CONTAINER.
BLOCK 8: SELECT CONTAINER CODE FROM BLOCK 5.
BLOCK 9: INSPECT STORED ITEM AND RECORD CONDITION (NC = NO CORROSION, C = CORROSION). IF "C" EXPLAIN IN BLOCK 12.
BLOCK 10: DATE OF TEST DISC INSPECTION.
BLOCK 11: RECORD COLOR AND SHADE OF TEST DISC (EXAMPLES: WHITE, LIGHT ORANGE, ORANGE, OR DARK ORANGE). CHANGE WILL FIRST APPEAR AS A SMALL IRREGULAR SPOT.
BLOCK 12: RECORD TPO NUMBER OR NSN OF CONTAINER AND COMMENTS. COMMENTS CAN BE CONTINUED ON BACK SIDE.
BLOCK 13: AFTER COMPLETION OF TEST, OPEN CONTAINER AND RECORD %R.H. OF REFERENCE CARD. ALSO AMBIENT TEMPERATURE IN °F.

NOTES: 1. CAUTION - TEST INDICATOR DISC IS AN IRREVERSIBLE TYPE. SEE TEST PLAN (PARA D) AND INSTALLATION INSTRUCTIONS (ATCH 3).
2. THIS DATA SHEET CAN ACCOMMODATE FOUR (4) DIFFERENT TESTS AT DIFFERENT SET-UP & INSPECTION INTERVALS.
3. WHEN TEST INDICATOR DISC CHANGES COLOR, TEST IS COMPLETE REGARDLESS OF REMAINING INSPECTION PERIODS (BLOCK 6).

SHEET NR. 1

Figure 3. Data Sheet

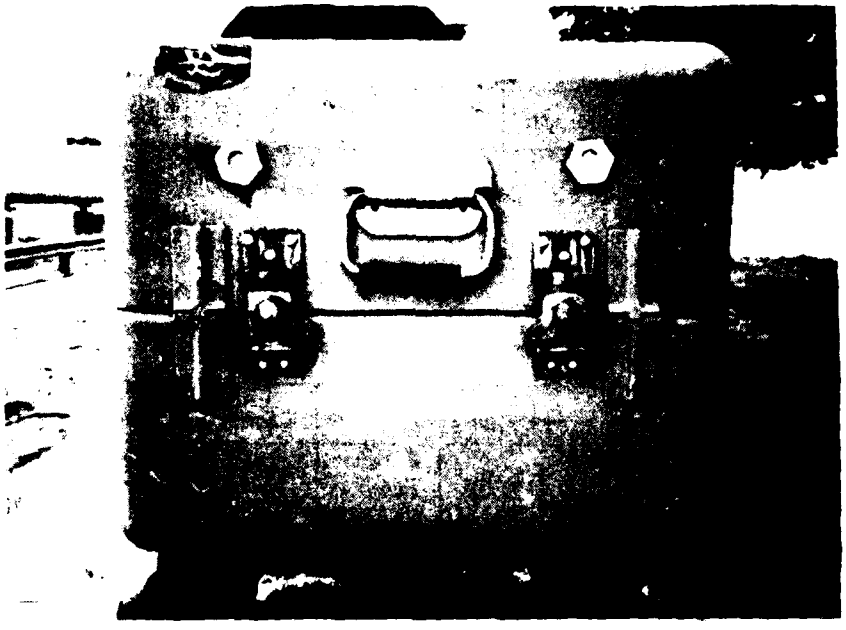

Figure 4. Photograph of AFPEA Test Container

TEST RESULTS

The test results are presented in a table format to better summarize the large amount of data accumulated during the year long field test. Additionally, the lack of actual show "turn-a-round" stored items required a breakout of the variations to show some of the deviations to the original test plan.

Table II summarizes the test data for all of the test containers. Table III identifies the container content while Tables IV and V breaks out the tripped indicator data versus type of contents.

Test Containers	Test Indicator Tripped		Test Indicator Tripped and Reference Indicator at 50% RH or less		Corroded Items or Test Plates		Elapsed Time Before Test Indicator Tripped					
							1-30 days		31-180 days		Over 180 days	
TOTAL	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
138	43	31	20	15	0*	0	19	14	22	16	10	7

* See comments at end of this section.

Table II. Consolidated Test Data

Containers With Stored Items		Containers With Test Plates		Empty Containers Without Desiccant	
NO.	%	NO.	%	NO.	%
86	62	36	26	16	12

Table III. Container Contents

NUMBER AND PERCENT OF TRIPPED INDICATORS								
STORED ITEMS			TEST PLATES			EMPTY CONTAINERS WITHOUT DESICCANT		
NO.	% OF TOTAL	% OF STORED ITEMS	NO.	% OF TOTAL	% OF TEST PLATES	NO.	% OF TOTAL	% OF EMPTY
14	10	16	21	15	58	16	12	100

Table IV. Tripped Indicators vs. Type Contents

TRIPPED INDICATORS WITH REFERENCE INDICATORS AT 50% RH OR LESS								
STORED ITEMS			TEST PLATES			EMPTY CONTAINERS WITHOUT DESICCANT		
NO.	% OF TOTAL	% OF STORED ITEMS	NO.	% OF TOTAL	% OF TEST PLATES	NO.	% OF TOTAL	% OF EMPTY
10	7	12	0	0	0	10	7	63

Table V. Reference Indicator at 50% RH or Less vs. Type Contents

During AFPEA's twelve month test period some of the test containers were rotated in different directions, relative to the sun, to determine the sun's effect on the indicators. The 3-spot reversible indicator was affected by direct sunlight and changed from blue to pink without a change in moisture content inside the container. The irreversible indicator was not affected. It remained white if not tripped and retained the dark brown color after tripping.

AFPEA's test container number 1E was periodically monitored after the twelve month test period and after the irreversible indicator tripped. Although the irreversible indicator did not change, the 3-spot reversible (40-50% range) cycled between blue and pink. The photograph of this container (Figure 5) was taken one day after the 3-spot indicator was all pink. The photograph

shows that the 50% range was reversing back to blue.

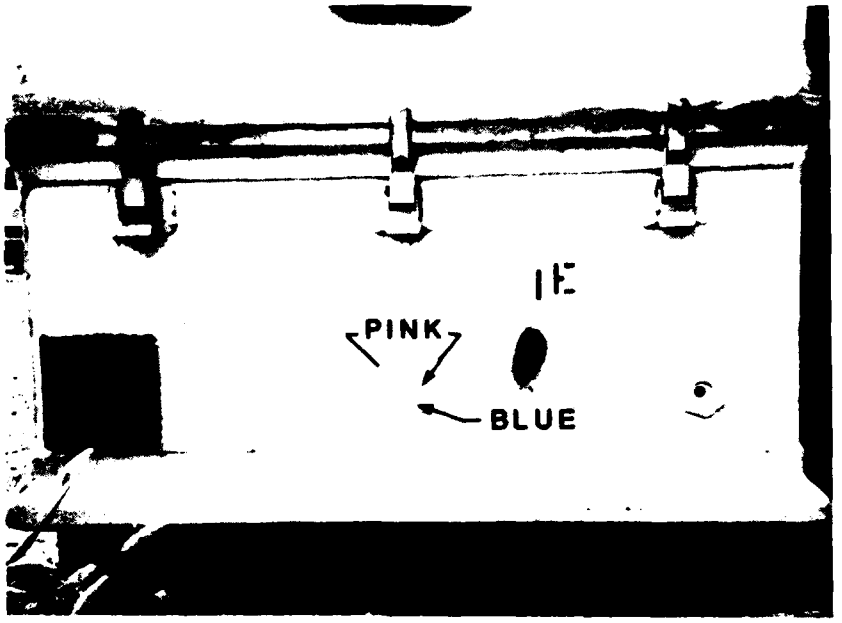

Figure 5. Photograph of Container with Reversible and Irreversible Indicators

Some of the Alameda's test plates did corrode but the corrosion data was not included in this report because the test plate was not inspected when the irreversible indicator tripped. Instead, the inspection occurred six to eleven months after exposure. Their explanation for the deviation was to determine if the indicators would reverse back to white or back to a lighter color. The indicators remained stained after the twelve month test period ended. Also, the five containers with eight ounces of tap water added were eliminated from the total number of test containers for the following reasons:

1. Not required by the test plan.

2. Indicators tripped the first day.

3. Water was not found in any of the other test containers.

DISCUSSION

Current packaging procedures which require the use of desiccant recommend that desiccant be replaced when the cobaltous chloride reversible indicators indicate a 40% RH or higher. The results of this field test revealed that no corrosion was evident after the items were exposed to RH levels of 55% (tripping of irreversible indicator). The use of the irreversible indicators could prove to be a step toward improvement of corrosion protection for the following reasons:

1. Added protection for items if moisture is present in containers even though the reversible indicator shows a safe condition.

2. Unnecessary replacement of desiccant if current reversible indicators give false readings.

3. Unaffected by temperature or sunlight.

In November 1982, a midtest evaluation questionnaire was sent to all participants. Thirteen responses were received and twelve of these indicated a favorable impression of the irreversible RH indicators. Forty-two (30%) of the 140 RH indicators changed color, thereby indicating that the containers were not properly sealed or the desiccant required replacement. Six of the thirteen responses identified a problem with gasket leaks. The survey also revealed that the most critical inspection period was within the first 24 to 48 hours after preparing the container for storage.

Observation of the dissolved crystals (see Figure 1) revealed that the amount of staining was stopped when the indicators were placed in a dry environment (55% RH or less). The indicator could be used as a gauge (reference point) to determine if the stored item was exposed to a small or large amount of moisture. Although no test data are available, a "judgment call" could be made, i.e., a small trace of the melted crystals on the indicator and no change at a later date may indicate that the amount of moisture exposure may not be damaging to the stored item. The other extreme (large stained area) would reveal item exposure to a large amount of moisture and the desiccant should be changed immediately. Additionally, the color shade could help to determine at approximately when the RH level exceeded 55%. If the color is orange, the RH level increase was recent. If dark brown or black, the exposure had taken place sometime ago.

Another observation concerning the irreversible indicator revealed that if the new (unused) indicators are not properly stored, staining of the indicator will occur. Although the indicator is packaged in a plastic MIL-B-22191C, Type II wrap (with desiccant) care should be taken to store in a dry environment. Normally, the packaged indicators are shipped in a one gallon metal container which would help to prevent premature exposure. AFPEA's "desk top" test of the packaged indicator (without the metal shipping container) revealed that the individually packaged indicators could be stored in a typical office environment for approximately one year without tripping.

CONCLUSIONS

The test results and the observations indicate that the irreversible humidity indicator tested:

1. Will provide a positive and permanent indication of early stage moisture intrusion before corrosion takes place.

2. Is not affected by sunlight.

3. Will not reverse color (will remain stained).

4. Requires care when storing unused indicators.

RECOMMENDATIONS

1. Official nomenclature and national stock number should be assigned.

2. Recommend the use of this indicator for all long term desiccated stored items, especially those items susceptible to fast corrosion.

3. To prevent exposure of unused indicators the manufacturer should provide one or more of the following improvements:

a. Package individual indicators with additional desiccant.

b. Replace the current MIL-B-22191C, Type II wrap with MIL-B-22191C, Type I to reduce the watervapor transmission rate (WVTR).

c. Provide caution marking on individual wrap to instruct user to store unused indicators in sealed metal containers such as the containers provided by the manufacturer.

d. Include indicator installation instructions in the metal container to caution the user not to install the indicator in the item shipping container until the shipping container is ready to be sealed. Also, include safe (maximum) time (minutes or hours) the indicator can be exposed to ambient conditions from the time it is removed from its protective wrap to the time it can be installed in the indicator plug (housing).

APPENDIX I

Participating organizations and points of contact (POC).

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APPENDIX II

Irreversible Indicator Installation Instructions

NOTE: Since the indicator is an irreversible type use caution when installing indicator. To prevent early activation of crystals, the indicator should not be exposed to high relative humidity prior to installation.

Before removing the irreversible indicator from the plastic envelope proceed as follows:

1. Open container and inspect item for signs of corrosion.

2. Remove the old reversible humidity indicator disc using a 1/2" (13 mm) hex key wrench. CAUTION: Do not install indicator yet.

3. Prepare container for resealing (inspect gasket and closure devices, etc.).

4. Replace desiccant in accordance with MIL-P-116 or other directives. Use fresh, dry desiccant.

5. When container is ready for closing, remove indicator from the plastic bag. NOTE: If indicator plug (housing) is removed from the container, reinstall plug in container before removing irreversible indicator from bag.

6. Place the indicator in the plug cavity.

7. Replace indicator retaining nut in the indicator plug and close container.

8. Inspect the indicator for staining the next day following the installation to determine if container seal is leaking.

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11. TITLE (Include Security Classification): (U) Field Test of Irreversible Indicator	
12. PERSONAL AUTHOR(S): JARVIS, FRANK C.	
13a. TYPE OF REPORT: FINAL; 13b. TIME COVERED: FROM Apr 82 TO Dec 83	14. DATE OF REPORT (Yr., Mo., Day): 1 December 1983; 15. PAGE COUNT: 21
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17. COSATI CODES — FIELD / GROUP / SUB GR	18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number): Irreversible humidity indicator, desiccant, storage, corrosion, shipping container, field test, packaging.

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

A. OBJECTIVE: To determine the effectiveness of irreversible relative humidity (RH) indicators in the storage environment of DOD organizations throughout the Continental United States (CONUS).

B. APPROACH: Twelve DOD organizations participated in a twelve month field test of irreversible RH indicators which were installed in various types of containers with a variety of items. The indicator, which turns to a dark orange/brown color after exposure at 55% RH, will not reverse (even in a dry environment) as do the blue (low RH)/pink (high RH) reversible type. The reversible type can be affected by temperature without a change in humidity.

C. SUMMARY: The test revealed that the indicator will provide a positive and permanent indication of early stage moisture intrusion before corrosion takes place. (Continued)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: UNCLASSIFIED/UNLIMITED [X] SAME AS RPT [ ] DTIC USERS [ ]	21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL: FRANK C. JARVIS	22b. TELEPHONE NUMBER (Include Area Code): (513) 255-2565; 22c. OFFICE SYMBOL: PTPP

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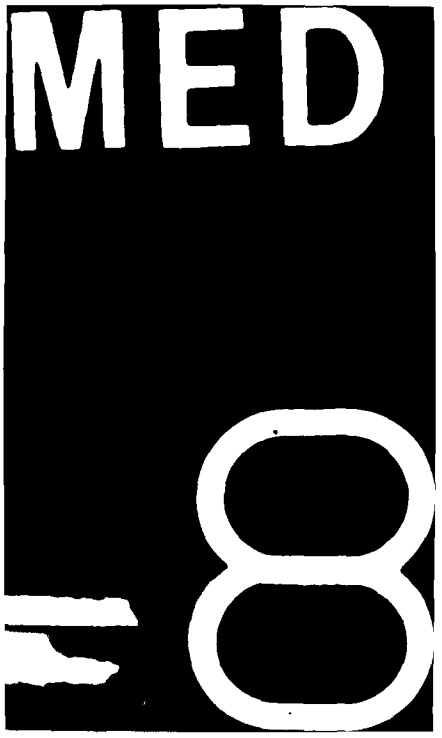
19. (Continued)

Additionally, the test revealed that 12% of the test containers with actual stored items indicated a RH above 55% even though the blue/pink reversible reference elements indicated RH levels below 50%.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